HOW PAPER IS MADE

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A PRIMER OF INFORMATION ABOUT THE MATERIALS AND PROCESSES OF MANUFACTURING PAPER FOR PRINTING AND WRITING

BY

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CONTENTS

HISTORICAL INTRODUCTION

WHEN mankind discovered the art of embodying its knowledge in writing progress toward civilization began. The preservation of the discoveries and acquirements of one generation for the enlightenment of succeeding generations, made possible through the art of writing, has enabled man to acquire an intellectual development that has gradually given to him mastery over the world.

Primitive man began his groping for a written language with the making of pictures, crude and simple to be sure, but fairly representative of what they were supposed to stand for. From this humble beginning man gradually progressed upward in the search for expressive signs and marks, the passing generations recording their deeds in ancient pictures, sound marks, hieroglyphics, cuneiform marks, syllabary signs, etc., until they reached the ancient Phœnician alphabet, and still following an upward course gradually evolved the Greek alphabet and then the Roman, which, with very little change, is our alphabet of today.

Obviously, early writing materials were as crude as the writing itself, and consequently we find that the surface of a stone, a bone, or a shell, a flat piece of wood, bark or leaf of a tree, a plate of metal, the facet of a gem, any one of a thousand things that could be used was employed for this purpose. The Egyptians and Greeks were in the habit of using even the fragments of broken pottery for their less important records. But the materials most used before the invention of paper were the Assyrian clay tablet, papyrus, and vellum.

A detailed description of these materials may be found in No. 49 of this series, "Books Before Printing."

Paper is said to have been invented by the Chinese at an unknown but very early date. It was introduced to Europe by the Arabs about the tenth century A. D. It was made of linen rags and did not vary much from the rag paper of today, except in finish. Paper was not much used in Europe until the invention of printing. Being much less substantial than vellum it did not commend itself to the makers of manuscript books. Paper was, however, immediately found to be much better suited to printing than any other material and with the advent of the printed book it very quickly superseded other materials for the purpose. Owing to its resemblance to papyrus it was given this name; the word being derived from the name of this ancient paper-making plant.

Fig. 1. Papyrus Plant.

Late in the nineteenth century some new materials in wood and other flexible fibers treated with chemicals and loaded with clay were adapted for making into sheets. These new materials have largely superseded the linen and cotton rags and are today the recognized paper-making material of commerce. Much of the paper made from these materials is far inferior to rag paper. The inferior qualities at any rate lack durability, even when not exposed to wear. They are good enough for the great number of uses where permanence is not required, but should not be used for books of permanent value—

records and historical matter, where there must be no doubt of the quality of the fiber employed and of the care used in manufacture. A fifteenth century book of rag paper is practically as good today as it was the day it was printed. Most of the paper now in use possesses no such lasting qualities.

HOW PAPER IS MADE

The Processes of Paper Making

MODERN paper manufacture requires certain successive operations, each of which is necessary to produce specific properties in a given paper. While the underlying operations may be the same in the production of different grades of paper, nevertheless there are marked variations of detail.

Paper manufacture may be divided into five general processes, viz.:—

1. Separation of paper-making fibre (cellulose) from raw material.
2. Converting the acquired cellulose into pulp.
3. The "beating" of the pulp.
4. Manufacturing the beaten pulp into paper.
5. Processes relating to finishing the paper.

SEPARATION OF CELLULOSE — Cellulose is the name given to all fibres of cellular growth; it makes no difference whether they come from cotton or linen rags, wood, or other vegetable matter. Under a powerful microscope you can see that these tiny hair-like things are hollow tubes, twisted, flattened, and torn more or less in the process of paper making. Not all cellulose fibres are alike. It depends upon whether they are cotton, linen, spruce, poplar, or what not. The walls of some are thicker than others, they vary in length, in strength, and in shape. Some are flat and smooth, some are spiral, others are irregular in shape, and all are connected with other tissue which is not cellulose.

The separation of cellulose from these other "foreign" tissues is the first step in paper manufacture and is accomplished by digestion or boiling of the raw material with alkali or acid salts at a fairly high temperature.

CONVERTING THE CELLULOSE INTO PULP — The next step is the conversion of this cellulose material into pulp or so-called "half stuff." This is accomplished by submitting the boiled material to a chemical disintegrating process whereby the fibres are isolated, conditioning the pulp so it may be readily bleached and prepared for the next operation.

THE "BEATING OF THE PULP" — The pulp or "half-stuff" is next conveyed to beating engines where the pulp is mixed with water and beaten with revolving iron bars until it acquires the desired fineness. It is during this process that the quality of the paper is determined more fully than in any other part of its manufacture.

Here different grades of "stock" are mixed to produce certain qualities; here, too, if at all, adulterants are put in and beaten together until all are thoroughly mixed. Coloring and "loading" of the pulp are also effected during the beating process.

MANUFACTURING THE BEATEN PULP INTO PAPER — This stage is the direct manufacture of the prepared material into paper form. All the preliminary operations are similar in principle and lead up to this final process of making the pulp into a sheet, whether the paper is hand-made or machine-made. The manufacturing processes vary, depending upon the kind of paper wanted, and consequently it is herein that individual skill is given full play.

PROCESSES RELATING TO FINISHING THE PAPER — These include sizing, calendering, coating, glazing,

cutting, sorting, and packing. There are also operations pertaining to finishing, such as surfacing, embossing, pasting, etc., producing thereby the many novelties and specialties of the paper-making art.

Printers' Need of Some Knowledge of Paper

A study of paper is an important matter for all printing apprentices, and especially for those who expect to become pressmen. It is equally important for the man in the office who has to do the buying or for the salesman who has so large an influence on the selection of the stock.

Proper selection of paper for a given piece of work is essential, and a knowledge of paper from the standpoint of its structure and adaptability to the particular work in hand is all important.

The best design or engraving, the most careful composition, the cleanest type, unless accompanied by a suitable paper will result in ineffective printing.

Many printers and buyers of printing do not realize the importance of selecting the right paper for a given job. Often it is not a matter of price but a simple question of choosing paper of the right structure, finish and color.

The pressman has to take the paper which is ordered through the office, or specified by a customer, and turn out as good a result as possible. For the protection of his own reputation, therefore, he should become a competent judge of paper, as the best make-ready may show poor results on faulty paper, or on paper not wisely selected.

If the paper is to blame, the pressman ought to know it and ought to be able to give intelligent reasons why it is to blame. Some pressmen are too apt to blame the paper when, as a matter of fact, the fault is with

the ink, with the engravings, or with themselves. Sometimes all these things may be right and yet, owing to atmospheric conditions, poor results follow. The skillful pressman, like the able doctor, should be able to size up the case and tell the cause of the trouble. A good knowledge of paper increases the value of a pressman to his employer in many ways. For example, the customs of the paper trade do not permit of the return of stock after it has been ruled, cut, or printed, hence it is important to form the habit of inspecting stock as soon as it is opened, so that delays and troubles on the press may be anticipated and avoided as far as possible. The practical knowledge that makes such foresight possible can be gained only by actual experience in the use of paper; no amount of reading on the subject is sufficient in itself to give it, but the book learning is valuable in the same way that a chart is valuable to a sailor. It points out the difficulties and opens his eyes to the possibilities. Therefore, whether you are craftsman, salesman, or manager, if you learn the main principles of paper making and the different properties of paper you will have the same advantage over one who does not as the sailor with a chart would have over the sailor who has to navigate by guesswork—you will be more valuable to your employer and more likely to earn promotion. The sections which follow, based on actual experience in paper mills, are intended to be merely a guide to a practical understanding of paper, and make no pretense of completeness.

The Basis of Paper

The varieties of paper are many, but the principal characteristics of all papers are the same. Tear any piece of paper and closely observe the torn edge. You will notice a hairy-looking fringe, and if you are very observant and tear the paper both lengthwise and cross-

wise of the sheet you will notice that it tears harder one way than the other. The reason for this will be explained later, but tear a piece of paper both ways now, carefully noticing this difference so that you will remember it. The little hairs in the fringe that you may easily see are the cellulose fibres which are matted together to make a sheet of paper.

Cellulose is the name given to all fibres of cellular growth; it makes no difference whether they come from cotton or linen rags or from wood. Under a powerful microscope you could see that these tiny hair-like things are hollow tubes, twisted, flattened, and torn more or less in the process of paper making. Not all cellulose fibres are alike. It depends upon whether they are cotton, linen, spruce, poplar, or what not. The walls of some are thicker than others, they vary in length, in strength, and in shape. Some are flat and smooth and look like one of those straws you get at a soda fountain, after it has collapsed, some are spiral, like a piece of twisted tape, others are irregular in shape and are connected with other tissue which is not cellulose.

The quality of the paper depends upon the character of the fibre and this, as you see, depends to quite an extent upon whether these fibres were derived from cotton, linen, or some sort of wood. It also largely depends on the skill of the manufacturer. There is one thing, however, in which they all are alike, and it is upon this one property that paper making depends. This property is of such basic importance that every sheet of paper is always affected by it just as long as it lasts.

This important property is *affinity for moisture.* Each little fibre will absorb, whenever it gets a chance, a surprising amount of moisture; it more than doubles its own weight when thoroughly wet. You can demonstrate this for yourself by soaking an ounce of paper

and weighing it on the letter scales. But what happens to these little fibres when they get so wet? That is the big secret of paper making! They expand. Not only do they get just a little longer, but they become much larger round and very, very limp and weak. You all know how easy it is to put your finger through wet paper, and now you know the reason why. All the crispness, all the strength, has come out of the little fibres, so instead of holding together, they may be separated easily, each from the other.

Another important thing to remember about these cellulose fibres is that they never become absolutely dry without artificial heating. It is their nature to retain within their walls an amount of water which varies according to the humidity of the air. There is a law of nature which governs the percentage of moisture in each fibre, making it dependent upon the amount of moisture in the air. Consequently the fibres are no more or less constant than the weather. When the moisture in the air increases, the fibre absorbs proportionately and expands; when the moisture in the air decreases, the fibre gives off moisture and shrinks. This change in any one fibre is of course very, very slight, although it may be measured by the use of the microscope, but when the thousands of little fibres side by side in a sheet of paper are moistened each requires a little more room, and the dimensions of the paper are perceptibly enlarged. Never think of a piece of paper as a dead, inert thing, but remember it is as much alive as a barometer, and this fact will explain many of the troubles which you as a printer encounter with paper.

We have seen how paper may be taken apart by the action of moisture. We will now see the part that water plays in putting a sheet of paper together, or, better, how it helps to put millions of cellulose fibres together

so that they form a sheet of paper; but first let us see how and where we get these fibres which form the basis of paper.

Cellulose from Rags

In the early days of the craft paper-making fibres were all obtained from cotton and linen rags, which are used today chiefly for bond and writing paper. These fibres are nearly pure cellulose and therefore need little chemical treatment for purifying, as compared with wood. The rags are sorted according to grade; for an old worn rag is decidedly inferior to the cuttings such as obtained from shirt factories.

Many people seem to think that rag paper is the finest sort of paper, without realizing that it makes a big difference whether the rags were white or colored, old or new. The white rags require less chemical treatment than colored and the new rags are stronger than old ones.

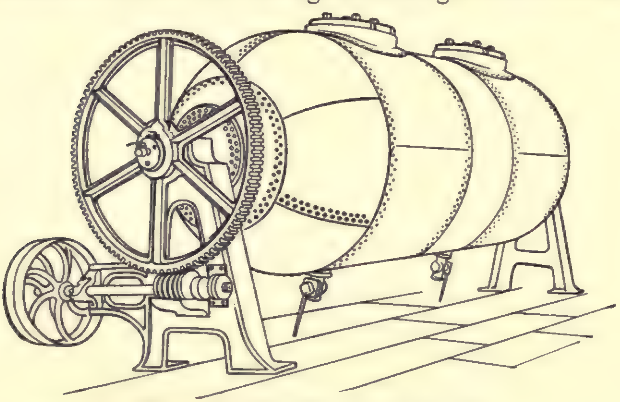


Fig. 2. Revolving Boiler for "cooking" rags.

When the rags are received by the mill they are first dusted by machine, then sorted and cut up into small pieces about the size of your hand. Next they are packed into large rotary boilers, where they are cooked

with lime for the purpose of dissolving any non-cellulose materials they may contain.

After cooking a sufficient time the lime has acted on these non-cellulose substances, making them soluble in water. The rags are then placed in the rag engines and washed, at the same time being reduced to a stringy pulp which consists of the pure cellulose fibres. The last thing is to bleach the fibres by adding chloride of lime. When this has been well mixed with the fibres the contents of the engines are run into drainers and allowed to stand a week or more. During this period the bleach liquor whitens the stock and is gradually evaporated. The water drains away the fibres like a snow heap in the drainer, ready to be dug out as needed. In this stage they are known as "half stock." Rope may be reduced to a pulp by a similar method and is used for making very strong papers such as tag board.

Cellulose from Wood

The first use of wood for paper making began in 1840. At that time it was reduced to pulp by grinding logs from which the bark had been removed. Paper made with this pulp is suitable for newspaper and other very cheap stock; it is quite unsuited for high-grade printing. The wood is composed of much besides the cellulose fibres, which comprise only about 53 per cent of its constituents. The rest is resinous and gummy material which is not of a permanent nature, as you may see for yourself by examining any old newspaper which has been lying in the sun. It is yellow and brittle.

About 1861 an American named Tilghman discovered a way of dissolving these undesirable portions of the wood by what is known as the sulphite process.

In this process the wood is freed by machinery from bark and knots and is then cut up into cubes half or three quarters of an inch in size by revolving cutters.

The cubes are then bruised by being passed through heavy iron rollers, so as to make it possible for the boiling solution to penetrate them thoroughly. They are next passed over a screen to sift out sawdust and sand, and are then thoroughly boiled in a solution of sulphurous acid combined with a certain amount of base, either magnesia or lime. The boilers are lined with lead, as the acid quickly destroys iron.

Another process, called the soda process, is similar except that the wood is boiled in a strong solution of caustic soda under a high steam pressure for seven or eight hours.

The pulp produced by the sulphite process is harsh and strong, making a hard, transparent paper. That produced by the soda process is soft and mellow.

It was not, however, until the early eighties that much was accomplished with chemical wood pulps. Now there are several different ways of getting cellulose fibres from wood, and all depend on chipping the logs into small pieces, after having removed the bark, and cooking these chips with some liquor which will dissolve the gums and resins but not harm the cellulose fibres.

All members of the vegetable kingdom, parasites excepted, can be made to yield cellulose to a greater or lesser extent. From this immense collection the sources which interest us can be reduced to a handful. These can be listed in the following five groups, with the usual treatment briefly given:

I. Rag Fibres — Linen, cotton. Mild alkaline boiling; low pressure; lime or caustic soda used; easy bleaching.

II. Grasses and Fibrous Plants — Esparto, straw, hemp, jute, etc. Boiled as with I, except that a little higher pressure and stronger liquor are used; harder bleaching than I.

III. Hard Woods — Gum, poplar, aspen, chestnut, birch, basswood, etc. Alkaline digestion; caustic soda;

high pressure and stronger liquor than I and II. Bleaches harder than I and easier than II.

IV. Soft or Evergreen Woods — Pine, spruce, hemlock, fir, balsam, etc. Acid digestion usually; high pressure for 6 to 7 hours; low pressure for 18 to 24 hours; commonly known as "sulfite"; bleaching depends on method of cooking.

Certain mills cook these woods by an alkaline sulfate process, giving "sulfate" pulp. "Kraft" papers come from undercooked sulfate pulp.

Caustic soda can also be used for cooking.

V. Ground Wood — Either hard or soft woods; untreated chemically and possess no strength or permanency.

So skilled have the pulp manufacturers now become that fine cellulose fibres are obtained by these chemical treatments. The two principal kinds of trees used at present are spruce and poplar. The spruce makes a strong pulp and the poplar a soft, weak pulp, usually called soda pulp because of the caustic soda used in the boiling.

Straw is reduced to a pulp by a similar process, but in this country is used principally for boards and cheap wrapping.

In England and Europe a very good pulp is made from esparto grass, which grows in Africa and Spain. Undoubtedly we shall soon find some other plant in this country from which cellulose fibres may be profitably obtained, as our wood supply is getting scarce.

To sum up, cellulose fibres may be obtained from cotton or linen rags, from rope, or from woods. The best fibres come from the better grade of rags, but excellent cellulose is also obtainable from wood. Straw and esparto also furnish raw material. Cellulose may be obtained from almost every plant, but only a few are commercially profitable to use at the present time.

The principle underlying the making of all pulps is the elimination by cooking with acids or alkalies of any substances in the raw material which are not cellulose. Papers that have been used may be made over again into pulp by boiling in soda ash to extract the printer's ink, then washing and bleaching to a white color.

In very cheap grades, such as box boards, the old papers may be used without preliminary treatment. In the United States old papers are an important source of raw material; 21 per cent of the fibres used in 1909 came from this source. This percentage was greatly increased by the shortage of paper-making material caused by the Great War of 1914. Printers should therefore save their waste and sell it as a by-product to paper stock dealers.

Table showing comparative per cent of cellulose, length, strength, bulking properties, and permanency of the fibres commonly used in this country, placing the highest in the scale at the head and working down:

Per Cent Cellulose	Av. Length of Fibres	Av. Breadth of Fibres	Comparative Strength	Bulking Properties	Permanency
Cotton	Linen	Pine	Linen	Esparto	Linen
Linen	Cotton	Hemlock	Cotton	Poplar	Cotton
Poplar	Pine	Spruce	Pine	Gum	Pine*
Gum	Spruce	Cotton	Spruce	Cotton	Spruce*
Pine	Hemlock	Poplar	Hemlock	Pine	Hemlock*
Spruce	Gum	Gum	Gum	Spruce	Esparto
Hemlock	Poplar	Linen	Straw	Hemlock	Straw
Esparto	Esparto	Esparto	Esparto	Linen	Poplar
Straw	Straw	Straw	Poplar	Straw	Gum

* From best grades of sulfite.

Other Materials Used in Paper Making

Although paper can be made from nothing but fibres, or a mixture of different fibres, the fibres are usually combined with other materials. Clay, talc, or other minerals are added in order to improve the capacity and printing qualities. Fine writing papers contain little if any clay, and, as you know, they are hard and harsh and would not be considered desirable for book printing even if the price permitted. The mineral filler gives a soft feel to the paper. It fills up the spaces between the fibres, which not only makes it possible to get a smooth finish, but prevents the paper from being too transparent. Coloring matter is used even in white papers, to which a little blue and a little pink are sparingly added so as to brighten the shade, for the same reason as bluing is used by laundry men.

Innumerable dyes and pigments are used for making colored papers. Few are really fast, and the best way to judge the colors for fastness is to expose them in bright sunlight and watch the result. The anilin colors, especially, are discharged by sunlight.

Sizing is used in most papers to prevent their being too absorbent. The best writing papers are surface sized by immersion in gelatine, but the larger number are sized by the use of rosin soap which is mixed up with the other ingredients before the paper is formed.

The easiest test for sizing is to moisten the paper very slightly, observing how quickly it dries. Writing fluid may also be used, as it is easy to see how fast it is absorbed.

Sundry chemicals are used in the production of pulp and in bleaching. It is important that the stock should be free from chemical residues which might result from careless or hasty treatment. Those of you who may have to do with lithography may encounter paper which

contains enough acid to etch the stone or the zinc printing surfaces slightly. The observation of such happenings should direct suspicion to the paper. The presence of sulphur or chlorine in the paper would also prove ruinous to bronzing, causing it to tarnish.

The Beater Room

We have touched upon the different raw materials at the paper maker's command, now let us see how he combines them.

One of the most important parts of the mill is known as the beater room, and here it is that the mixtures of stock are made. The beating engine consists of a large

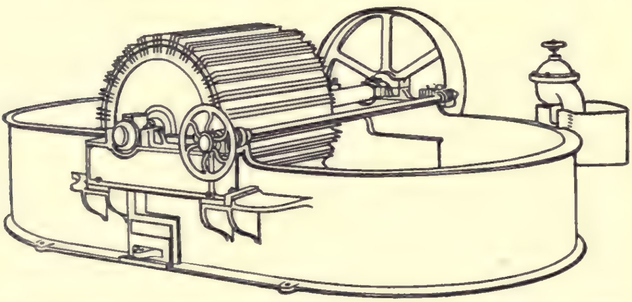


Fig. 3. Engine for beating paper pulp, with cover removed to show beater cylinder.

oval tub about four feet deep. It is divided into halves by a partition which stops short of the ends, thus leaving a channel. On one side of the partition, located about two-thirds of the way from one end, is a large casing reminding one of the paddle-wheel box on a steamer. Within this casing turns a large cylinder, perhaps forty-eight inches in diameter. A series of iron knives are set into the surface crosswise. They stick out about an inch and there is a little space between the blades. Directly underneath the roll is a bed plate which also has a set of knives. The roll may

be raised or lowered over this plate, so as to regulate the cutting of the pulp which passes between the roll and the plate. Into this engine are dumped gradually whatever pulp and other ingredients may be needed. A large quantity of water is also used which is kept in motion by the beater roll, so that a continuous circulation is maintained which carries the stuff under the beater roll. In this process all the tiny fibres of the pulp become separated and mixed up with the size, the mineral filler, and the coloring matter. By adjusting the roll the fibres may be shortened. The length of time taken for beating the stock also has a marked effect on the outcome.

In addition to the beating engine, another type of refining engine called a Jordan is used. This is conical in shape. The interior is lined with knives. There is also a core having the outside covered with knives, which revolves on a shaft inside. This cone-shaped core may be adjusted to bring its knives into close relations with the knives on the inside of the shell, thus controlling the grinding of the pulp as it passes through. The outlet from the beater flows into a tank to feed the Jordan engine, which in turn discharges into what is called the machine chest, that is, the reservoir from which the liquid paper-making stuff is pumped onto the paper-making machine.

The Machine Room

We have now traced the processes of paper-making from the rag-picker's cart and the forest logs through the pulp-making processes and the beater room where all the ingredients are mixed to the actual formation of the paper itself. Stuff prepared as has been described is of a gruelly consistency, but is thinned by the addition of water just before it reaches the paper machine. If you took some in the hollow of your hand you would

be surprised at the large quantity of water in which the fibres are suspended.

It is at this point that I would again remind you of the effect water has upon each individual cellulose fibre, how flaccid and enlarged each becomes through absorption.

A hand mold, such as was used in early paper making, looks more like a fly screen than anything else with which you are familiar. If you should take such a mold and dip it into a vat of paper stuff and then,

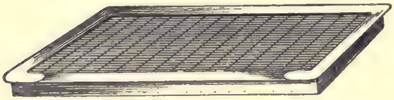


Fig. 4. Hand Mold for making "laid" paper.

holding it level, lift it out of the vat, you would find a thin layer of fibres covering the wire. A shaking motion immediately applied would improve the formation of the sheet. The fibres would be deposited by the water and caught on top of the wire cloth just as you might catch fish with a net. This is actually the first step in making paper by hand. The second and more difficult step is to remove the tender white film of paper in process. It is accomplished by inverting the mold and pressing the paper film evenly upon a moistened piece of felt. The film adheres to the felt and the mold comes away clean, ready for making another sheet.

Over the new sheet of paper is laid a second piece of felt, upon which in turn another piece of paper is laid, and so on until a small pile of alternating felt and paper has accumulated. This is transferred to a press where the water is partially squeezed out. It is not possible even under great pressure to force those little fibres to relinquish all their water; at best they will contain almost fifty or sixty per cent of moisture. It remains, therefore, to dry out what is left, and as has been previously pointed out even air-dried paper retains some moisture.

This discharge of water by pressure and drying has been working a strange change in the paper fibres. It is practically the reverse of wetting paper. All the while the fibres have been contracting, but as they lie criss-cross of one another just where the water deposited them this contraction acts like the clasping of hands and each little fibre forms a closer bond with its neighbors, so that when the pile of new-formed sheets is removed from the press it is no longer gruelly in consistency, but has assumed considerable firmness so that as the felts are peeled off each sheet of paper may be lifted intact and hung up to dry. With the evaporation of the abnormal moisture the crispness returns to the fibres and the sheet finally attains the condition with which we are all so familiar.

Making paper by machinery is merely a mechanical reproduction of the steps just described, the inventive genius of men having shown them how to make in a continuous web what formerly could only be made in sheets of small size.

The Fourdrinier paper machine has an endless wire-cloth belt, technically known as "the wire." This is supported on a frame in a horizontal position by various rolls which keep it taut and level. The paper stuff flows out upon one end of this wire and is kept from running over the edges by means of rubber "deckle straps." The sheet is continuously formed by the deposit of fibres as the water pours through the wire and a sideways shaking motion of the frame helps to form the sheet evenly.

The farther the pulp is carried along the wire the solider it becomes, since the water keeps draining away. This drainage is quickened by suction boxes over which the wire drags. Just beyond the last suction box is situated a wire-covered roll called a "dandy," which turns as the paper passes under it. If it is desired to

have a watermark in the paper, the requisite design is soldered on the surface of the dandy roll and consequently is imprinted into the moist paper. By using dandy rolls with different covers either wove or laid paper can be made.

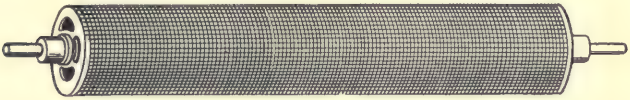


Fig. 5. Dandy Roll for making "wove" paper.

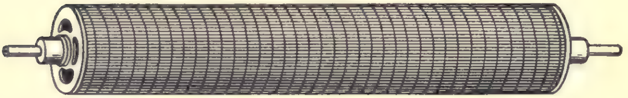


Fig. 6. Dandy Roll for making "laid" paper.

Following now the course of the paper along the machine, we find that the wire passes around a large roll on top of which turns another large roll called the couch roll, which is covered by a felt jacket. The pressure between these rolls gives sufficient firmness to the web so that it may be passed onto endless felt belts which carry it through two or more pairs of press rolls, and finally it is carried over to the "dryers." The dryers are heated cylinders over which the paper passes and the number of which varies on different machines, but their duty is to evaporate the water from the paper as it passes along to the calender stacks, where the finish is given.

There is another type of machine called the cylinder, in which the formation of the paper takes place quite differently. The paper stuff is admitted into a vat in which there is a revolving hollow cylinder covered with wire cloth similar to what is used on the Fourdrinier machine. One end of this cylinder opens into a sluice-

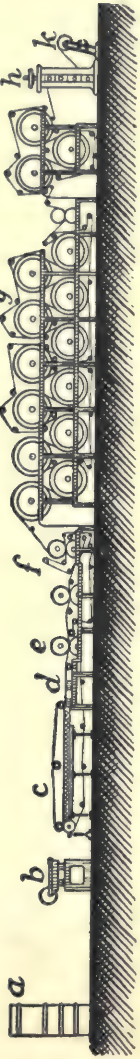


Fig. 7. Diagrammatic plan of paper-making machine. *a*, stuff chest; *b*, strainers; *c*, wire screen; *d*, suction boxes; *e*, couch rolls; *f*, press rolls; *g*, drying cylinders; *h*, calender rolls; *k*, reelers.

way through which the water which carries the fibres into the vat escapes, leaving the wire covering of the revolving cylinder plastered with a film of fibres. An endless felt runs tangent to the cylinder and is held in close contact with it by a couch roll. The pressure of this roll causes the paper to stick to the felt and thus a continuous web of paper is formed. This felt may run tangent to several other molds and by this means very thick paper may be made. The rest of the machine is the same as the first one described.

The paper passing over dryers and through calender rolls is finally wound upon a reel the full width of the machine. As soon as one reel is full the paper web is broken down and a second reel is started. The first reel is then wound off into rolls which are cut by slitters into the desired width.

The weight of the paper is varied both by the speed of the machine and the volume of stuff which is admitted. If an antique finish is called for the paper is not calendered at all, but is wound upon the reel just as it comes from the drying cylinder.

A calender stack consists of two frames which support a stack of chilled-iron rolls. By passing the paper through the stack between these rolls the surface is smoothed. The smoothness depends upon the

number of rolls which are used and may be varied as the occasion requires. A higher finish than that known as machine finish is obtained on a special calender stack separate from the paper machine, called a super-calender. In this stack there are a number of hard paper rolls alternating with the chilled-iron rolls,

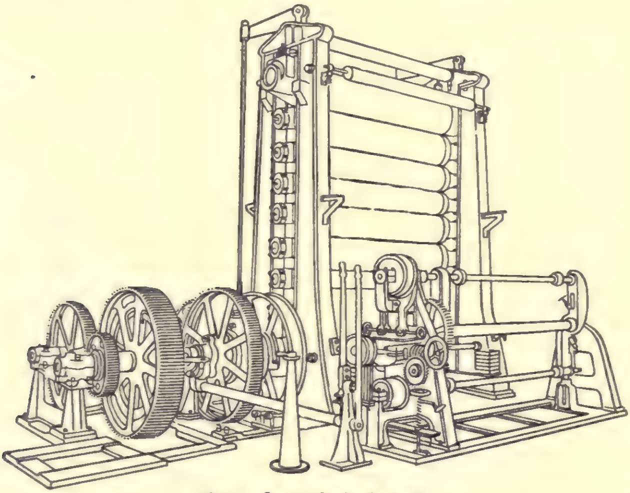


Fig. 8. Stack of calender rolls.

and before passing through the rolls the web of paper is steamed. This results in a smooth shiny surface, but greatly reduces the thickness of the paper. In fact an antique paper is about twice as thick as a super-calendered paper of the same weight.

Coated Paper

The highest possible finish can only be obtained by coating. Paper for this purpose is made with a medium finish and wound into rolls. The rolls are transferred to the coating machine, which brushes onto the paper, as it winds off the roll, a mixture of blanc fixe and casein

and coloring. The casein is an adhesive and serves to make the mineral surface stick to the paper. The paper so treated is carried through a drying room in festoons at the end of which it is again wound into a roll. In this stage of the process there is no glaze to the surface. The polish is obtained by running the sheet through super-calenders. The dull-finished coated papers are made in the same way but receive very little calendering. If the paper is well made it has a splendid printing surface for fine half-tones. The most frequent trouble you may meet with, in printing coated paper, that is not encountered with uncoated paper is the picking off of the surface. As a rule the cause would be poor adhesive quality in the coating. Occasionally the trouble is induced by the use of ink which is too "tacky" or stiff, so that it sticks to the coating and pulls it off onto the rollers.

Special Finishes

Returning to the subject of uncoated papers, aside from the finishes already described there are linen, crash, ripple, and other surfacings quite common in bond and cover stocks. These are usually obtained by a plating process. Linen finish, for instance, is obtained by interleaving the sheets of paper with sheets of linen and zinc plates. A few of these at a time are passed back and forth between heavy plater rolls so as to impress the pattern of the cloth into the paper.

Much may be said in their favor from the standpoint of style, but the farther we depart from a smooth surface the more care is required of the pressman to get a clean result and the harder it is on the type which has to be forced into the paper to reach the depressions.

We will go no farther into the details of manufacture, as it is more important for you to understand the physical make-up of paper than the process of manufacture.

Physical Characteristics of Paper

If you have ever observed logs or sticks floating down a stream you must have noticed that they tend to point in the direction of the current and not across it. The same is true of the little cellulose fibres streaming along the paper machine. This tendency is partly offset by the sideways shaking of the wire at the point where the stuff first flows on, but the result is a distinct grain in the paper which has important effects in the finished sheet. The grain runs in the direction the paper stuff flows.

If you will cut two pieces of paper, two inches by four, out of a sheet in such a way as to have the grain run the long direction of one and the short direction of the other, you can make the following observations:

First, put the two pieces together so that they will exactly cover each other. Now hold on to them by one end in such a way that they would stand out horizontally if they were perfectly stiff. If the under piece has the grain crossways it will fall away from the top piece

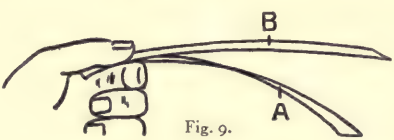


Fig. 9.

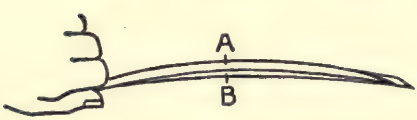


Fig. 10.

at the free end (see Fig. 9), but if the grain runs the long way in the under piece the free ends will not part (see Fig. 10). This is because paper is stiffer across the grain. The experiment is a good method of telling

which way the grain runs in a sheet of paper. Now take the two pieces and fold each of them once, into a square. Notice that the fold is cleaner in the piece where the grain was crossways. Fold them again in the opposite direction so as to make two strips one inch by four inches, and you will find the neater fold in the piece where the grain was lengthways. This is because in folding across the grain you break the fibres, but there are few broken fibres in folding with the grain. If you pull the strips in halves you will notice that it is easier to break the strip with the grain lengthways, as this merely separates the fibres with little resistance; but to break the strip with the grain crossways necessitates breaking practically every fibre.

Let us note two examples of the practical value of this knowledge. In making a book the grain of the paper should run up and down the page, in order that the book may be flexible and open comfortably. A cross-grained book will not usually stay opened by itself. If you were cutting up some stock to make bands for use in a laundry around the shirts, you should cut them with the grain the long way, so as to obtain the greatest possible tensile strength.

Other examples will turn up in your experience where the direction of the grain is important. Just remember that the flexibility, stiffness, and tensile strength of a given piece of paper depend on cutting it to advantage in accordance with the grain.

Now cut out two or more strips of paper one inch wide and twelve inches long with the grain lengthwise in one and crosswise in the other. Place them together to make sure they are exactly the same length. Make a mark on a piece of smooth board, then measure off twelve inches and make another mark. Next take the paper strips one by one, pass each through a basin of water and place them on the board with one end pre-

cisely on the first mark. You will be surprised to see how much longer one strip becomes than the other owing to the expansion of the moistened fibre. If you recall the fact that the fibres enlarge more in diameter than in length, you should at once be able to conclude which way the grain runs in either strip of paper. Of course the strip with the crosswise grain expands more than the one in which the grain runs lengthwise, but the latter would become a bit the wider of the two. The longer the strips with which you experiment the greater will be the total expansion, for the expansion of the whole strip depends upon how many fibres lying side by side, as it were, have become swollen.

The practical application of this characteristic of paper may be seen in the following examples. If you were printing a color job, and after the first color was printed a change occurred in the weather, with greatly increased humidity, the paper would expand. If the grain ran crossways in some sheets and lengthwise in others the register of the second color would be far worse in the cross-grained sheet. It might not be very serious in the sheet with the grain lengthwise, because its expansion would be less. For example, suppose conditions change so that a sheet of paper will expand $\frac{4}{32}$ of an inch per foot across the grain and $\frac{1}{32}$ of an inch per foot with the grain. A sheet 24 x 36 inches with the grain the 36-inch way would then expand to $24\frac{8}{32} \times 36\frac{3}{32}$ inches; but had the grain run the 24-inch way the sheet would expand to $24\frac{2}{32} \times 36\frac{12}{32}$ inches. In the first case the maximum expansion would come in the shorter dimension and would be $\frac{1}{4}$-inch. In the second case the maximum expansion would come in the longer dimension and would be $\frac{3}{8}$-inch.

Therefore, in all work requiring close register the possible trouble from poor register may be minimized by having the grain run the long way of the sheet. If,

when printing such a job, you experience a sudden big change in the weather, the safest way is to hold up on another printing until the weather, or rather the relative humidity, returns to the point where it stood when the job was begun. Some papers give more trouble than others in this respect because they have been dried too much in manufacture and in the exposure of the press room the paper immediately begins to absorb its normal quantity of moisture. Such paper is in an unstable condition, regardless of weather conditions, and is certain to be troublesome unless it is dried thoroughly before using.

The second practical example of the influence of moisture on the paper is that of wavy edges. The wave occurs most markedly across the grain, because paper as it lies in the ream can absorb only through the exposed fibres. These end fibres take up the moisture first and expand. The middle does not expand. The moisture does not penetrate very far into the pile, hence the larger portion of the sheet does not expand; if it all could be exposed the whole sheet would expand about equally, but under the conditions described the moistened section buckles and waves.

These waves create trouble in feeding into the press, as there is more or less variation to which the grippers cannot be adjusted. This is another reason why it is desirable that the grain should run the long way of the sheet, as it insures a better gripper edge.

Static Electricity in Paper

The amount of moisture in the air has a marked effect on the behavior of paper in relation to what is called frictional or static electricity. You have very likely noticed when combing your hair in cold weather how hard it is to make the hair lie flat; it seems to be magnetized by the comb. This is because it has become

charged by the combing with electricity. Paper very easily becomes charged with electricity. In fairly warm to hot weather it is rarely noticeable. This is because the electricity is conducted off by means of the moisture and dust particles in the air, moisture being a medium through which electricity may pass. Dry air acts like an insulator for electricity, as it holds little moisture. The colder it gets the less moisture it holds and the better insulation it offers; consequently the frictional electricity stored in the paper has no means of escape. It causes a lot of trouble, as the sheets of paper, being magnetized, stick together or adhere to the fly bars on the press. In other instances the sheets seem repelled from one another and will not lie down flat as they are delivered from the press.

Paper is normally in a neutral electrical condition; in other words, there is usually no manifestation of the presence of an electrical charge in it. Under the influence of friction or pressure, however, the neutral condition is disturbed and a difference of "electrical potential" is set up, positive or negative frictional or static electricity becoming manifest in the paper, and the opposite in whatever produced the friction or pressure. Paper being a non-conductor of electricity, the charge, positive or negative, remains fixed. As electricity always seeks to escape to earth, or seeks to combine with a charge of the opposite kind, this force is imparted to the substance in which the charge is fixed. The charged material now has the property of strongly adhering to anything with which it comes in contact. In small quantities of paper it is easier to dissipate the magnetic influence than when paper is in large bulk. Medium and light-weight highly calendered and coated papers, when printed on cylinder presses, are often liable to be troublesome in delivering the sheets without off-set. The delivering of the sheet alone is often a difficult

problem regardless of whether or not there is an off-set of ink. Thick paper does not usually give much trouble, the greatest difficulty occurring with thin, highly calendered paper. Various methods of overcoming the trouble have been devised, but few have proved successful except under favorable conditions. Grounded wires with contact points to touch the sheet as it passes, placed near the cylinder or delivery table of the press, to draw off the electricity, have at times been effective. A pet-cock may be left open in the steam radiator so as to moisten the air, or any other means of getting moisture into the air may be beneficially used.

The tympan of the press may be moistened with glycerin or some patent "electric neutralizer." The maintenance of warmth in the press room over night and Sundays or holidays is helpful, because warm air can hold more moisture than cold air. Some people have found that tinsel, such as is used in decorating Christmas trees, is useful as a conductor, if arranged so that the sheets of paper brush by it. Of course the ends should be grounded.

There is a machine for neutralizing electricity in paper, called an electrical neutralizer, which by means of an alternating current of electricity thoroughly neutralizes the static electricity in the sheets of paper. The alternating current has, as its name implies, both positive and negative charges, "and in the presence of such a current the charges on the paper become their own destroyers," as they draw out of the alternating current the kind and quantity of electricity which is just sufficient for complete neutralization.

Sizes and Weights

Paper may be made any size which is desired, the width being regulated on the paper machine and the length of the sheets being fixed by an adjustment of

the rotary cutters which cut off the sheets from the rolls. Certain sizes most in demand have been standardized and are carried in stock by the dealers. There are some local variations and so many different sorts of paper that no classification will be here attempted. All this information can be obtained from jobbers' price lists, which are easily procured.

Odd sizes have to be made to order and the requirements of mills differ as to the minimum amount of such special order that will be accepted, varying from 1000 pounds to 10,000 pounds according to kind, color, and other specifications.

One thing to be learned is to calculate the ream weight of any size sheet from a given basis. We will take the following problem for example:

A ream of paper 25 x 38 inches weighs 60 pounds.* The same kind of paper and thickness of sheet is wanted in sheets 32 x 44 inches. Obviously a ream of the latter weighs more than the former, but let us find out how much. First find the areas of the two sheets; then multiply the area of the ream of the unknown weight by the weight of the given ream, and divide the product by the area of the given ream:

$25 \times 38 = 950$ inches. $32 \times 44 = 1408$ inches.

$1408 \times 60 = 84480 \div 950 = 88.9$ pounds.

Therefore, if a ream of the smaller size weighs 60 pounds, a ream of larger sheets of the same stock would weigh 88.9 pounds. As ream weights are usually only approximate rather than exact, this would be calculated as either 88 or 90 pounds to the ream.

The thickness of paper may be measured by a micrometer gage. Paper gages vary in price from

* The ream weight of book paper is customarily based on the size of 25 x 38 inches, the standard size for this class of paper. When printers or dealers speak of a 60-pound or an 80-pound paper it is understood that this is the weight of a ream of 25 x 38, unless another size is specified distinctly.

five dollars up. In measuring thin papers it is well to gage four thicknesses at a time, as this lessens the chance of error. The readings are in thousands of an inch.

Substance Number Basis for Paper

Most kinds of paper are bought and sold by the pound. Formerly, an arbitrary base size and ream weight were designated which the manufacturer approximated in other sizes and weights. For example, if a printer ran a job on 17 x 22-20-pound bond, and afterwards as a matter of convenience wished to run a larger form on the same work requiring a sheet 17 x 28, he could buy the large sheet, but the weight would not be the same per square inch. It would weigh either more or less and also vary in thickness.

Under the Substance Number Basis which is now being adopted by many paper mills a certain size and weight for each class of paper is designated and all other sizes are standardized on this basis. Under this system the size and substance number only are indicated.

The standard size on bonds is 17 x 22 in base weights of 13, 16, 20, 24, 28, 32, 36 and 40 pounds per ream of this size. All other sizes are standardized on this basis. To illustrate: A 17 x 22-20 is considered No. 20. All other sizes on the same basis of weight will be ream marked No. 20 and sold at the comparative weight. Example: 20-pound 17 x 22 is No. 20. In 17 x 28 it is still No. 20, but weighs 25.4 pounds. You pay for ream weight.

Sizes of Writing Paper and their Names

10 x 16 Flat letter.	19 x 30 Double crown.
13 x 16 Flat foolscap.	20 x 24 Wedding royal.
14 x 17 Flat cap.	20 x 25 Index royal.
15 x 19 Crown.	20 x 28 Super royal.
16 x 21 Demy.	21 x 32 Double demy, broad.
16 x 26 Typewriter double cap.	23 x 28 Elephant.
17 x 22 Folio.	23 x 31 Imperial.
17 x 28 Double cap.	23 x 34 Colombier.
17 x 24 Check folio.	26 x 33 Atlas.
18 x 23 Medium.	27 x 40 Double elephant.
19 x 24 Royal.	31 x 53 Antiquarian.
19 x 26 Check royal.	48 x 72 Emperor.

(The large sizes are not commonly carried in stock.)

Supplementary Reading

THE MANUFACTURE OF PAPER — By R. W. Sindall. An elementary text-book giving an outline of the various stages of paper manufacture. 275 pages, 58 illustrations. Van Nostrand, New York.

PRACTICAL PAPERMAKING — By George Clapperton. A general treatise covering the whole field. 236 pages, illustrated.

PAPER AND ITS USES — By Edward A. Dawe. A treatise for printers, stationers, and others. Samples of paper. 160 pages, 26 illustrations.

THE ART OF PAPERMAKING — By A. Watt. A handbook of manufacture, description of machinery and appliances, etc. 260 pages, 86 illustrations.

THE MANUFACTURE OF PAPER — By Charles T. Davis. A treatise on modern paper manufacture, with reference to American practice and machinery. 608 pages, 180 illustrations.

PAPER TECHNOLOGY — By R. W. Sindall. Treating of the manufacture, physical qualities, and chemical constituents of paper and paper fibres. 254 pages, 158 illustrations.

FROM PAPER MILL TO PRESS ROOM — By William B. Wheelwright. Published by the Inland Printer Co., Chicago, 1916.

A NEW LIGHT ON THE RENAISSANCE — By Harold Bailey. An interesting essay on early water-marks and printers' marks.

NOTE

Upon the following pages are printed photographic illustrations showing the principal stages in the manufacture of writing paper from rags.

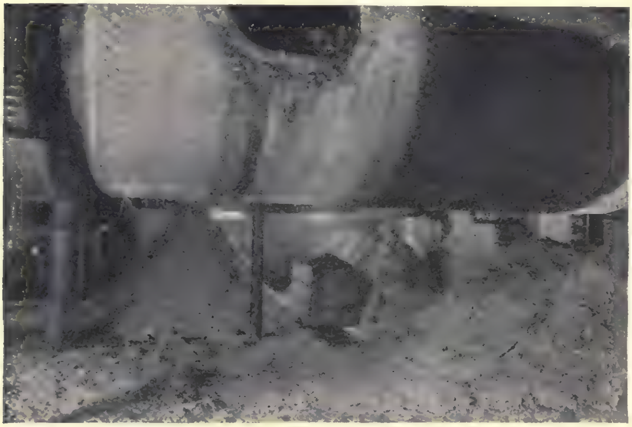
These engravings were contributed by the B. D. Rising Paper Company, of Housatonic, Massachusetts.

THE COMMENCEMENT OF THE PROCESS
Rags in bales of about 750 pounds each are received at the mill.

DRESSING THE RAGS
The rags as received contain many buttons, hooks and many other hard substances. These are cut off by knives. Buttons abound in the rags, and each girl has in front of her a heavy upright knife like a broad-bladed scythe, which does service in cutting off these buttons. Behind her are two or three enormous baskets into which the different sortings of rags are thrown.

READY TO BE BOILED

The rags are next cut into pieces three or four inches square and are mechanically dusted. The rags shown above are about to go through manholes into the bleach-boilers to be boiled, in order to loosen color and foreign matter.



RAGS AFTER BOILING

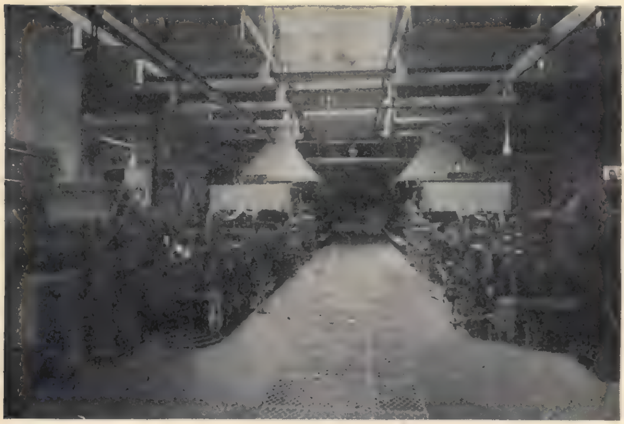
The boilers receive steam through the journals and rotate slowly. About twelve thousand pounds of rags are boiled at a time, with lime and soda to loosen the color and remove impurities. When the boiling is completed the manholes are opened and the stock is discharged upon the floor. After cooling, it is conveyed to the washers.

WASHING AND BEATING

The rags are here washed in clear water which flows in and is carried away continuously. Necessary chemicals are added and the stock is washed white. It then runs into drainer vaults. When ready to be made into paper, the stock is brought up and "beaten" or drawn out further till the required length of fiber is obtained.

THE STUFF CHESTS

From the beaters the stock runs into the stuff chests. There it is mixed by an agitator which looks like the paddles of a big ice cream freezer. This process renders the color uniform. From the stuff chests the stock is pumped over baffle plates and magnets, which remove any sand, bits of iron or similar impurities.



FOURDRINIER MACHINES—WET END

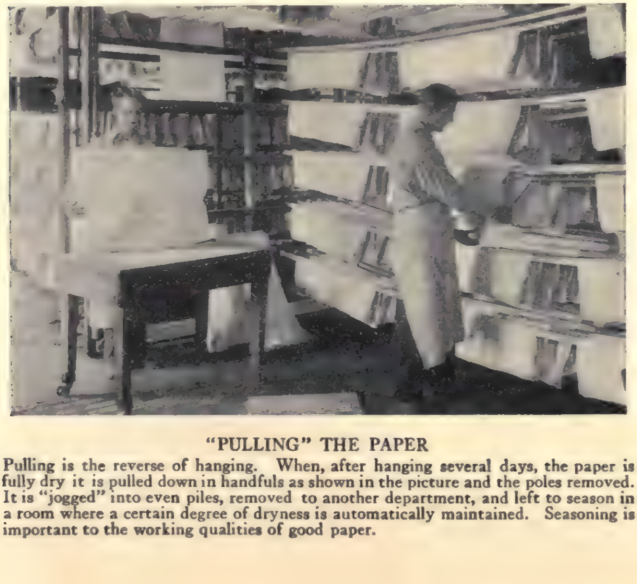
After being strained through screen-plates to remove strings or lumps, the stock runs onto the Fourdrinier machine, an endless moving sieve or "wire," shaken with a sidewise motion to remove the water from the stock and to felt the fibres together into paper. A heavy rubber band or "deckle" keeps the stock from flowing over the edge of the wire. A roll with designs on it presses a mark into the sheet. The mark is pressed into the paper when wet, hence the term "watermark."

FOURDRINIER MACHINES—CUTTER END

After receiving the watermark, the paper runs between several sets of rolls covered with felts which squeeze out the water and solidify the sheet. Then, in continuous web, it passes around revolving steam-heated drums on which it dries. From this point the paper is run through a bath of "animal size" to fill the pores, so that ink will not penetrate, and then is run between rubber rolls, to remove the excess of size. It is cut into sheets, and laid off wet in piles.

POLE DRYING

From the Fourdrinier machines the paper is taken to the loft in packs, where a workman with a T-shaped stick hangs it on poles, as shown in the picture. When the loft has been filled, heat is turned on and the paper slowly dried. Loft-dried paper is from 10 to 25 per cent. stronger than the same stock machine dried.



"PULLING" THE PAPER

Pulling is the reverse of hanging. When, after hanging several days, the paper is fully dry it is pulled down in handfuls as shown in the picture and the poles removed. It is "jogged" into even piles, removed to another department, and left to season in a room where a certain degree of dryness is automatically maintained. Seasoning is important to the working qualities of good paper.

THE FINISHING ROOM, SHOWING SORTERS AND CALENDERS

From the lofts the rough paper is taken to the calender room to be "finished." The calenders, shown at the right, are machines made up of rolls revolving against one another. The rough paper is fed one sheet at a time between the rolls. By varying the pressure on the rolls, and the number of times through, different degrees of smoothness can be obtained.

PLATER FINISHING

Plater finishing is smoothing the paper by means of plates of zinc or other material. A "book," consisting of alternate sheets of paper and plates, is run under heavy pressure between the rolls of the machine shown in the center. By adding linen cloths between the plates, linen-finished paper is produced. Many beautiful effects are obtained by varying this method.

SORTING

After calendering, the paper goes to the sorters. Each sheet is inspected and imperfect sheets are removed. The paper is then counted into reams, trimmed, wrapped, and labeled.

SUGGESTIONS TO STUDENTS AND INSTRUCTORS

The following questions, based on the contents of this pamphlet, are intended to serve (1) as a guide to the study of the text, (2) as an aid to the student in putting the information contained into definite statements without actually memorizing the text, (3) as a means of securing from the student a reproduction of the information in his own words.

A careful following of the questions by the reader will insure full acquaintance with every part of the text, avoiding the accidental omission of what might be of value. These primers are so condensed that nothing should be omitted.

In teaching from these books it is very important that these questions and such others as may occur to the teacher should be made the basis of frequent written work, and of final examinations.

The importance of written work cannot be overstated. It not only assures knowledge of material but the power to express that knowledge correctly and in good form.

If this written work can be submitted to the teacher in printed form it will be doubly useful.

QUESTIONS

1. What art is essential to the development of civilization, and why?
2. Sketch briefly the development of marks indicating ideas.
3. What were the substances earliest used for bearing these marks?
4. What were the most important ancient writing materials?
5. What is the modern writing material and where and by whom was it introduced into Europe?
6. What is the latest type of this material and what are its advantages and disadvantages?
7. What are the five general processes in paper making?
8. Tell briefly what is done in each process.
9. What is the value of a knowledge of paper, especially to the pressman?
10. What do you notice when you tear a piece of paper?
11. What is cellulose?

12. Upon what does the quality of paper depend?
13. What important property is common to all cellulose fibres?
14. How does this property affect the fibres?
15. What else is important to remember about paper?
16. How is paper affected by the condition of the air?
17. What sorts of paper are now made from rags, and why?
18. How are rags graded for paper stock?
19. How are rags treated to make paper?
20. When was wood first used for paper making?
21. What is wood pulp paper good for, and what not?
22. How much of the wood is cellulose, and what is the rest?
23. Who discovered the sulphite process, and when?
24. Describe the sulphite process.
25. Describe the soda process.
26. What is the difference in the pulps produced by these processes?
27. What are the common features of all methods of making wood pulp?
28. What woods are mainly used?
29. What other materials are used?
30. What use may be made of old paper?
31. What other materials are used in making paper?
32. How may dyes be tested?
33. What is sizing?
34. How may it be tested?
35. What is the effect of the presence of chemicals in paper?
36. How are the materials combined?
37. Describe the common beater engine.
38. Describe the Jordan engine.
39. What is done to the material after it leaves the beater and before it reaches the paper machine?
40. Describe the process of making paper by hand.

41. How is the moisture removed from hand-made paper?
42. Describe the process of making paper on a Fourdrinier machine.
43. Describe the operation of the cylinder machine.
44. What is calendering, and how is it done?
45. How is an antique finish procured?
46. What is super-calendering, and how is it done?
47. Describe the process of coating paper.
48. What is coated paper used for and what difficulties occur in its use?
49. Name some special finishes, and tell how they are produced.
50. What is meant by the grain of paper?
51. How does the grain of paper run?
52. What qualities of paper depend on cutting in proper relation to grain?
53. How should the grain run in book paper, and why?
54. How does the grain of the paper affect its action under moisture?
55. How does this quality affect the securing of accurate register?
56. What is the cause of wavy edges in paper, and what trouble do they cause?
57. How is static electricity in paper affected by atmospheric conditions?
58. What does static electricity cause paper to do, and why?
59. Describe some simple devices for overcoming difficulties in the press room.
60. Are the sizes and weights of paper fixed or standardized?
61. How is the ream weight of any size of paper calculated from a given basis?
62. Explain the "Substance Number Basis" for paper.

GLOSSARY OF TERMS RELATING TO PAPER AND PAPER MAKING

ALKALI — A term applied in commerce to the carbonates of soda and potash; and to the hydrates, the latter being designated caustic alkalies.

ANIMAL SIZED — A term applied to any paper which has been sized with gelatin.

ANIMAL SIZE — A term applied to glue or gelatin used in sizing high-class papers.

ANILINE — A coal-tar product, used as a basis for aniline dyes. Originally prepared from indigo, from which the name has been derived.

ANTIQUE — A light bulky paper having a soft velvety feel, used largely for novels and standard works of fiction. Made of or mixed with chemical wood pulp, uncalendered, and containing no loading as a rule.

BERIUM SULPHATE — A heavy mineral known as blanc fixe, heavy spar. When ground to powder, used as a filler for paper, and as an ingredient in satin white used for coated papers.

BIBLE — A strong, thin paper, used for Bibles originally, in which *opacity* is a chief characteristic, obtained by careful boiling and beating of rag. Wood pulp is now used in cheaper qualities.

BLANC FIXE — See *Barium Sulphate*.

BLANK — A common white cardboard of low grade wood pulp with fairly smooth surface, made in several varieties, plain blank, pasted blank, coated blank, etc.

BINDER'S BOARD — A hard polished card, used for the base of stiff covers, etc.

BEATER — The large cylinder with knives across its surface, revolving in the vat where the washed rags are beaten into fine pulp.

BLOTTING — An unsized highly absorbent paper, used as the name implies. Best qualities made from soft old muslin rags, sometimes tendered by chemical treatment. Cheaper qualities from soft wood pulps.

BLEACHING POWDER — Used for bleaching pulp and fibres of every description. A dry pulverulent powder of pungent odor prepared by exposing dry powdered quicklime to chlorine gas. It yields a clear solution of chloride of lime, when extracted with water.

BOGUS — A term used to denote an article or material of inferior or counterfeit nature. Bogus bristol, an imitation bristol card-

board made of low grade wood pulp. Bogus manila, an imitation manila paper. Bogus wrapper, a coarse, brittle, wrapping paper made from refuse material; it is cheap, and has little strength.

Box Boards — Used for box-making of all kinds, and manufactured from mechanical wood pulp, old waste papers, hemp, etc.

Bulk — The relative thickness of sheets of paper.

Bond Papers — Made of the finest writing-paper stock, with a special view to strength. They are made from white rags of the best quality, *i. e.*, new cotton and linen cuttings.

Box Papers — Paper used for covering boxes, stiff book covers, etc., made in a variety of colorings, and qualities; it is thinner than usual cover papers, so that it may be pasted down easily.

Bristol Boards — High-class cardboards first made at Bristol, from which the name is derived.

Calcium Sulphate — Used as a filler for papers. Known under several trade names according to the method of preparation, as follows: Gypsum, powdered gypsum, sulphate of lime, powdered plaster, terra alba, satinite, mineral white.

Carbon Paper — Used for the production of duplicate copies of bills, invoices, and similar documents. Prepared by surfacing thin tissues with a mixture of lampblack and fatty substances such as lard.

Cardboards — A general term applied to thick, stiff paper, or to the stiff board obtained by pasting layers of paper over one another.

Cartridge — A term used to denote ordinary qualities of drawing papers, made from rag or wood pulp, being strong, tough and opaque. Word originally confined to paper used for cartridge making, but now somewhat loosely applied.

Casings — A term applied to a certain size of packing paper. Exact origin of word uncertain, probably due to the paper having been used for lining purposes originally.

Casein — An albuminous substance obtained from milk by the action of sulphuric acid. Insoluble in water, but soluble in weak solution of ammonia, soda, and borax. Used for sizing of papers, and as an adhesive in the manufacture of coated papers.

Cassie — A term once used to describe the few outside sheets of a ream of good paper; from the French *casser*, to break or waste.

Chromo — A heavily-coated paper used in chromo-lithography. The body usually stout esparto paper; the surface somewhat dull and more absorbent than an art paper. The term is derived from the Greek word meaning color.

Caustic Soda — A powerful alkali prepared by boiling carbonate of soda with quicklime. Used for isolating cellulose or paper-making fibre from plants. Used under suitable conditions has little or no action upon cellulose. Dissolves animal fibres, such as silk and wool, readily.

China Clay — A substance, known also as Kaolin, formed naturally by the weathering of felspathic rocks, and consisting of silicate of alumina. Used as a loading for paper.

Chloride of Lime — Bleaching powder, used for bleaching pulp and fibres of every description. A dry pulverulent powder of pungent odor prepared by exposing dry powdered quicklime to chlorine gas.

Chlorine — A greenish gas of pungent odor prepared by heating hydrochloric acid (spirits of salts) with manganese dioxide. Absorbed by dry lime it yields bleaching powder. Fibres previously boiled in caustic soda are readily bleached when exposed to chlorine gas.

Calendering — The process of producing a smooth finish on paper by means of polished rollers.

Coal-tar Colors — So called because the colors are derived from organic substances found in coal tar.

Coated — A general term applied to papers which are surfaced on one or both sides with an adhesive mixture of a mineral substance and glue.

Colored Coated — Paper of the class just referred to which has a distinctive color, away from white, India tint, or cream.

Coated Label — A thin paper of strong quality coated on one side only; especially for labels.

Cover — Thick, heavy rag or wood paper, usually rough machine finished, but often variously surfaced, and soft sized; used, as the name implies, for covers to pamphlets, catalogs, and cheap books. Usually sent out in deep, strong, artistic colors.

Cylinder Machine — A paper-making machine in which the pulp is carried from the vat on the surface of a large wire cylinder, instead of on a constantly moving horizontal wire screen. Thick papers are usually made on cylinder machines, where the films from two or more cylinders can be run together to form a thick sheet.

Couch Roll — A felt covered roller which takes the freshly formed sheet from the wire screen and passes it along to the pressing and drying rollers.

Cooking — The process of boiling and dissolving fibrous raw material for paper.

DECKLE-EDGED — Paper from which the deckle edges have not been removed. The rough edge is due to the pulp being in contact with the deckle or frame of the paper mold, and when dry this edge is always rough. The deckle edge of genuine handmade paper can be imitated in machine-made paper.

DUPLEX — Paper having differently colored surfaces prepared in various ways. (*a*) On a coating-machine, each side being coated with a colored mixture; (*b*) By passing simultaneously two wet sheets of paper differently colored, through heavy couch rolls at the wet end of a paper machine. Used for programs, pamphlets, covers, advertisements, etc.

DANDY ROLL — A light wire cylinder attached to paper making machines. The wet web of paper carried along on the endless wire passes under this dandy roll and receives the impression of the wires. The arrangement of the wires determines the *laid* or *wove* pattern of the sheet, and letters or designs on this wire produce the water-mark.

ELEPHANT — High-class drawing paper measuring 28 inches by 33. Name probably due to the use of an elephant as the water-mark, but origin of same uncertain. This size, with slight variations, now used for printings and paper-hangings.

EMBOSSED — Paper upon which a raised or depressed design has been forced by means of special steel rollers, the surface of which has been cut to a particular pattern.

ENAMEL — A term applied in various ways to (*a*) cheap highly polished coated papers used for box covers; (*b*) to cards coated with a mixture of zinc white and glue.

ENGINE-SIZED — Sometimes called E. S. papers, because the sizing is effected by adding the rosin size to the pulp in the beating engine.

ENGINE SIZE — A term sometimes applied to rosin size.

ESPARTO — A grass peculiar to Spain and Algeria suitable for magazine papers. On treatment with caustic soda it yields 45 per cent. of paper-making fibre. Largely used in Europe.

FILLER — A substance added to paper pulp to fill up the minute interstices between the fibres to produce a smoother surface.

FIRST SORTING — Perfect paper which has been carefully inspected, sheet by sheet, and is free from specks, wrinkles, and all imperfections; the best manufacture of its grade.

FLINT — Papers, usually coated, to which an extra polish has been imparted by friction with a long flat stone moving quickly to and fro across the surface of the paper as it comes through the calenders.

Foil — Paper coated with tin, copper, or zinc in the form of metallic powder. Used for decorative or packing purposes.

Fourdrinier Paper — A name which defines the method of manufacture by the most improved machines. Papers thus made show nearly equal strength when torn in any direction and are thicker for their weight than cylinder papers.

Friction Glazed — Paper specially glazed or calendered by a stack of calenders in which some rolls are of small diameter and revolve at a much higher speed than the others, thereby creating friction against the paper.

Flats — Applied especially to common writing papers, sold by makers and dealers in flat packages of standard sizes; papers which come from the mill in flat sheets without fold or crease.

Fibre — A fine thread-like substance, as of wood, vegetable, or other tissue; especially any substance that may be separated and then woven or felted into a sheet or similar form.

Gelatin — A colorless transparent substance insoluble in cold water, used for tub-sizing the best qualities of rag paper.

Glue — A crude form of gelatin obtained by boiling down scraps of hide and bones. Used in sizing papers, in preparing enamel for coated papers, etc.

Grease-proof — A paper of thick or thin substance used as a wrapper, for jam-pot covers, and packing food of a greasy nature. May be a genuine vegetable parchment or merely an imitation.

Gummed — Ordinary papers coated with common gum or with dextrine.

Gypsum — A natural sulphate of lime. When ground into a fine powder used as a filler for paper under various fancy names. (Calcium sulphite)—A substance insoluble in water, produced by passing sulphurous acid gas into milk of lime, or lime-water. It is formed as an intermediate product in the preparation of bisulphate liquor, the gas converting it into a soluble bisulphate of lime. Used also as an antichlor.

Glazed — A surface of smooth, shiny polish.

Grain — The general direction of the fibres in machine-made paper.

Half-Stuff — The paper pulp in its first stage of preparation, freed from the valueless substances and partially prepared.

Hand-made — A general term applied to papers made on hand molds, as distinct from machine-made papers, or of a character in imitation of hand-made.

Hemp — A plant yielding fibre of great strength. It comes to the paper mill in the form of canvas, sailcloth, ropes, etc., and passes

through the usual operation. Mixed with cotton and linen rags makes an excellent paper.

India Paper — A thin, yellowish, absorbent paper, used for printing fine engravings, etchings, etc.; the genuine made in Oriental countries from vegetable fibres. The common kind is an imitation, made very thin, tough, and opaque, used largely for Bibles and prayerbooks.

Ingrain — A fancy name for mottled papers.

Jordan Engine — See page 22 for explanation.

Jute — Originally an Asiatic herb, but now grown in other countries. In America, the Indian Mallow, the fibre of which is used for manufacture of coarse sacking and bags, and gunny. Raw material used by paper-makers is the old gunny and sacking.

Kaolin — A substance formed naturally by the weathering of felspathic rocks, and consisting of silicate of alumina. Used as a loading for paper. The term is now applied to any kind of porcelain clay which does not discolor in the process of firing.

Kraft Paper — Brown papers made of soda wood pulp of high-class quality, and designated by the German word kraft, meaning strength.

Laid — Papers made on a laid mold, or with a laid dandy-roll. A laid paper held up to the light appears to be water-marked by a number of lines laid close together, intersected by lines at right angles placed about one inch apart, the effect being due to the formation of the mold or dandy-roll.

Ledger — Strong account-book papers, made from high-class rag, colored more or less blue, tub-sized, and well rolled.

Ledger Bristol — Made of No. 1 rags or strictly No. 1 bleached sulphite of long fibre that will give strength and make the sheet hard and snappy, so that it will stand hard treatment. It is used to a certain extent for making index cards for use in business and libraries and has to be made of a substance that will stand a great deal of wear. It is made on a Fourdrinier machine and afterwards heavily animal-sized and loft dried, thus allowing the sizing to mature and harden. This gives to the bristol a heavy writing and erasing surface, thus enabling one to write, erase, re-write, and re-erase several times thereon.

Lime — Calcium oxide, or quicklime. A caustic powder obtained by roasting limestone or marble.

Linen — Term usually confined to the cuttings and rags received by the paper-maker. The linen fibres are the best fibres of the

flax plant. Drawing or writing papers containing, in the genuine, no fibrous ingredient except linen rag.

LITHO — (Contracted form of lithographic.) A soft-sized, smooth paper, carefully made and dried, so that when moistened during the various printing operations the expansion or stretch is very slight. Used for illustrations and color printing.

LITHO BOARD — A slightly sized, soft cardboard, similar to litho paper.

LOFT-DRIED — A term applied to any papers dried by being hung up in a drying-shed or loft and finished by a natural process of evaporation of the moisture.

LOADING — A term applied to the various substances employed for the purpose, as is commonly supposed, of making paper heavy. Substances like China clay, kaolin, etc., are not added simply to give weight, but they serve to produce a smoother surface and to increase the opacity of the paper. Sometimes called filler.

M. PAPER is that which is not up to the first sorting, but in which the imperfections are trivial, perceptible only to the expert.

MACHINE-FINISHED — Any papers glazed and calendered by a calender which is placed at the end of a paper-machine in which the paper passes direct from drying-cylinders to calender. Usually abbreviated to M. F.

MANIFOLD — A thin copying paper, or slightly waxed tissue, used for interleaving order-books, letter copying-books, invoice forms, etc.

MANILA — A strong paper, supposed to be made entirely of manila hemp. The term now loosely applied to many papers made entirely of chemical wood pulp. Used for bookbinding, tags, musical instruments, etc.

MANILA HEMP — A plant found in the Philippine Islands. The fibre is strong and very suitable for ropes, which, when old, yield excellent paper pulp.

MAP BOND — A thin, strong, crisp paper used for printing maps.

MECHANICAL WOOD PULP — Pulp prepared by grinding wood against stones in the presence of water. So called because the process is purely mechanical, rather than chemical.

MARBLE — Used for covers of school exercise-books and note-books. Prepared by floating common thin papers on a bath of gum tragacanth, the surface of which has been sprinkled with various colors, and combed out to a desired pattern. Cheaper qualities prepared by colors sprinkled by revolving brushes on the sheet of paper as it travels continuously forward.

MIDDLES — Name given to common cardboard prepared from waste papers or mechanical wood pulp. Used as a cheap basis for surfaced cards, produced by pasting paper of good quality on this cheap cardboard. Hence the suggestive name.

MILLBOARD — Boards made of wood pulp, waste papers, and all kinds of fibre refuse. Usually well rolled or milled.

MUSIC — A thick, soft, opaque printing paper, not hard-sized and only slightly calendered. Used as its name implies.

N. PAPER — Is inferior to the M. grade, and in which specks and wrinkles are common.

NEWS — Common machine-finished, soft-sized printings, made from mechanical and chemical wood pulps, and containing usually 70 per cent. of mechanical.

OPACITY — The reverse of transparency.

OXFORD BIBLE — A special rag paper, strong, opaque, and thin, prepared by careful beating of selected rag.

ONIONSKIN is a term given to light weight papers that are used for second sheets, manifolding, etc. The name undoubtedly is given because the glazed or smooth surfaced stock resembles in appearance the outside skin of an onion. The particular characteristics are transparency, strength, and thinness for the weight, and the fact that the paper will lie flat and smooth at all times. The best quality of onionskin is made from all linen or all new cotton rags, but the large volume used in a general commercial way is made from pure, bleached sulphite wood pulp. Intermediate grades are made from varying combinations of cotton rags and sulphite.

PAPIER-MACHÉ — Waste papers pulped, mixed with mineral matter, such as China clay, rosin, etc., and afterwards molded into a variety of goods by steel dies, the manufactured articles being chiefly for domestic use.

PARCHMENT — The skin of calf, sheep, or goat, specially prepared for writing purposes. Now used for important documents only. The term is now applied also to well-beaten rag and wood pulp papers of good quality.

PARCHMENT PAPER — Prepared by dipping unsized paper into sulphuric acid of about 1.50 specific gravity and subsequently washing out all the acid.

PASTEBOARD — Common board made by covering middles with pastings.

PARAFFIN PAPER is grease proof and air tight, preservatives; articles wrapped with it do not stick to the paper. It is most made of wood pulp and paraffin wax.

PLATE — Rag paper of good quality, sometimes made of several thicknesses of unsized paper caused to adhere by great pressure when moist. Slightly tub-sized and sometimes calendered on one side only. Used for steel-plate engravings, from which the name is derived.

PLATE-GLAZED — Paper glazed by being placed between zinc or copper plates, which are then passed through steel rollers under great pressure.

POSTER PAPER — Common printing paper, used for the production of advertisements for bill-posting and outdoor display. Best qualities are strong and well sized.

PERFECT PAPER has been carefully inspected, sheet by sheet, and is free from specks, wrinkles, and all imperfections; the best manufacture of its grade.

PRESS BOARD is about three hundredths of an inch thick, with a smooth surface, used in finished knit goods and in hosiery mills in hot hydraulic presses to give an appearance similar to ironing. It is made of cotton and linen rags cut into very small shreds and run over a screen which takes the water out, then pressed thin between rolls, then wound around a roller many times to the required thickness, dried, and calendered to give the hard shiny appearance.

PULP — The soft, moist or dry, mass of material prepared to be made into paper sheets.

PULP BOARD — A thick coarse card made of mechanical pulp; used for boxes, packing purposes, etc.

PHOTO MOUNT — A very thick card made of good stock, with an outside finish in a variety of colors and finishes; made especially for mounting pictures, prints, etc.

RESIN — A term usually employed to designate the natural oxidized essential oils found in trees. Synonymous with rosin.

ROSIN — Same as resin, though the former term is often specially applied to colophony, the particular resin of the southern pine, which is the residue from the distillation of turpentine.

ROSIN SIZE — A compound formed by boiling powdered rosin with carbonate of soda. Soluble in water, and used for sizing paper in the beating engine.

SIZE — A solution of gelatinous substances, like glue, starch, or resin, used to glaze a surface.

SAFETY — Paper used for checks, coupons, and similar purposes. Generally the color is very sensitive to acids and alkalies. The pulp is impregnated with salts, such as iodides or bismuth, coal-tar dyes, manganese sulphate.

SODA — Name commonly applied to carbonate of soda. One of the most important chemicals for industrial purposes, manufactured from common salt. When causticized with quicklime it is converted into caustic soda, which latter substance is required for the digestion of fibres. Soda is used in the paper mill for the preparation of rosin size, for softening water, and for manufacture of caustic soda.

SODA PULP — Pulp prepared by digesting wood with caustic soda. The name is frequently misapplied to pulp prepared by the sulphate process.

SPENT LIQUOR — The waste lyes run off from digesters after the fibre has been boiled. Soda lyes can be recovered. Sulphite lyes are usually thrown away.

SPRUCE — The tree, par excellence, for the manufacture of chemical and mechanical wood pulp. Easily yields a strong fibrous pulp when treated by the sulphite process.

STARCH — Used as a sizing material in blottings, and to improve the surface and finish of high-class papers.

STRAW BOARDS — Box and packing boards made of straw pulp which has received very little chemical treatment.

SULPHATE WOOD PULP — Often called soda pulp; prepared by digesting wood with a mixture of sulphate of soda, caustic soda, and sulphide of soda.

SULPHITE LIQUOR — The solution of calcium bisulphite and free sulphurous acid used for the preparation of sulphite wood pulp.

SUPERCALENDERED — Paper, both printing and writing, which have been glazed in the supercalender.

SUPERFINE — A term denoting extra quality.

SUPERGLAZED — A paper with extra finish.

TAG — A very strong card used for shipping tags and for work requiring much handling; usually manila card board.

TALC — A mineral substance of different varieties and colors, granular, fibrous or compact, soft, greasy. When powdered it is used as a lubricant for toilet powder, and as an ingredient in clay coating for papers.

TISSUE — Very thin papers of many varieties, usually unsized, nearly transparent, so called originally not from its texture but from its use in separating the folds of fine silk tissue.

Tracing — Paper rendered transparent for tracing purposes by being soaked in a solution containing a mixture of Canada balsam, turpentine, and a trace of vegetable oil, and then hung up until dry.

Tub-sized — Paper is sometimes sized by being dipped into a vat or tub of animal size; in distinction from engine sized, or when the size is mixed in the pulp.

Vegetable Parchment — Paper rendered waterproof and grease-proof and partially transparent by having been dipped into a mixture of sulphuric acid and water for a few seconds and immediately washed in fresh water, traces of acid being finally neutralized with weak alkali. Used for jam-pot covers, etc.

Vellum — A thick writing paper somewhat resembling real vellum or prepared calfskin in appearance, made from high-class rags, which have been subjected to long beating.

Water-marked — Any paper containing a water-mark, or distinct design in the fabric, produced by the raised pattern on a mold or a dandy-roll.

Water-proof — Various sorts; (*a*) Roofing and tar papers; (*b*) imitation parchments and greaseproofs; (*c*) oiled papers; (*d*) special qualities prepared by soaking paper in a solution of shellac, with or without borax.

Wire — The screen on which the pulp flows to be formed into a sheet.

Wedding — A term employed to denote a class of high-grade papers and cardboard, of heavy weight and medium smooth finish, used for wedding and social announcements, cards, etc.

Wood Pulp — A general term for paper made from wood pulp. Qualities numerous.

Wood-pulp Boards — See Pulp Board.

Wove — A term applied to paper made on a woven wire, in which the wires cross and recross at even distances apart in a manner quite distinct from laid wires.

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